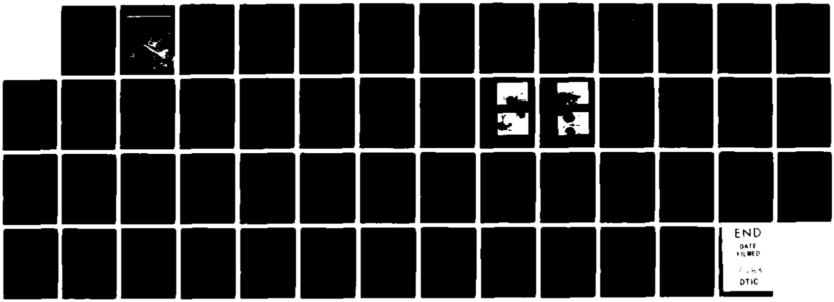
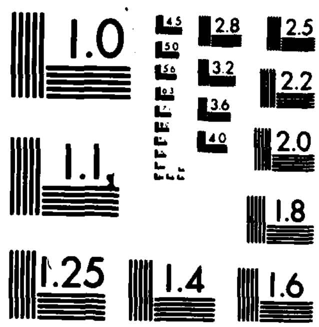
AD-A129 331 LORAIN HARBOR OHIO EROSION AND SEDIMENTATION STUDY 1/1
VOLUME III MAIN REPORT(U) CORPS OF ENGINEERS BUFFALO NY
BUFFALO DISTRICT MAR 83

UNCLASSIFIED F/G 8/8 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Draft
Final Feasibility Report

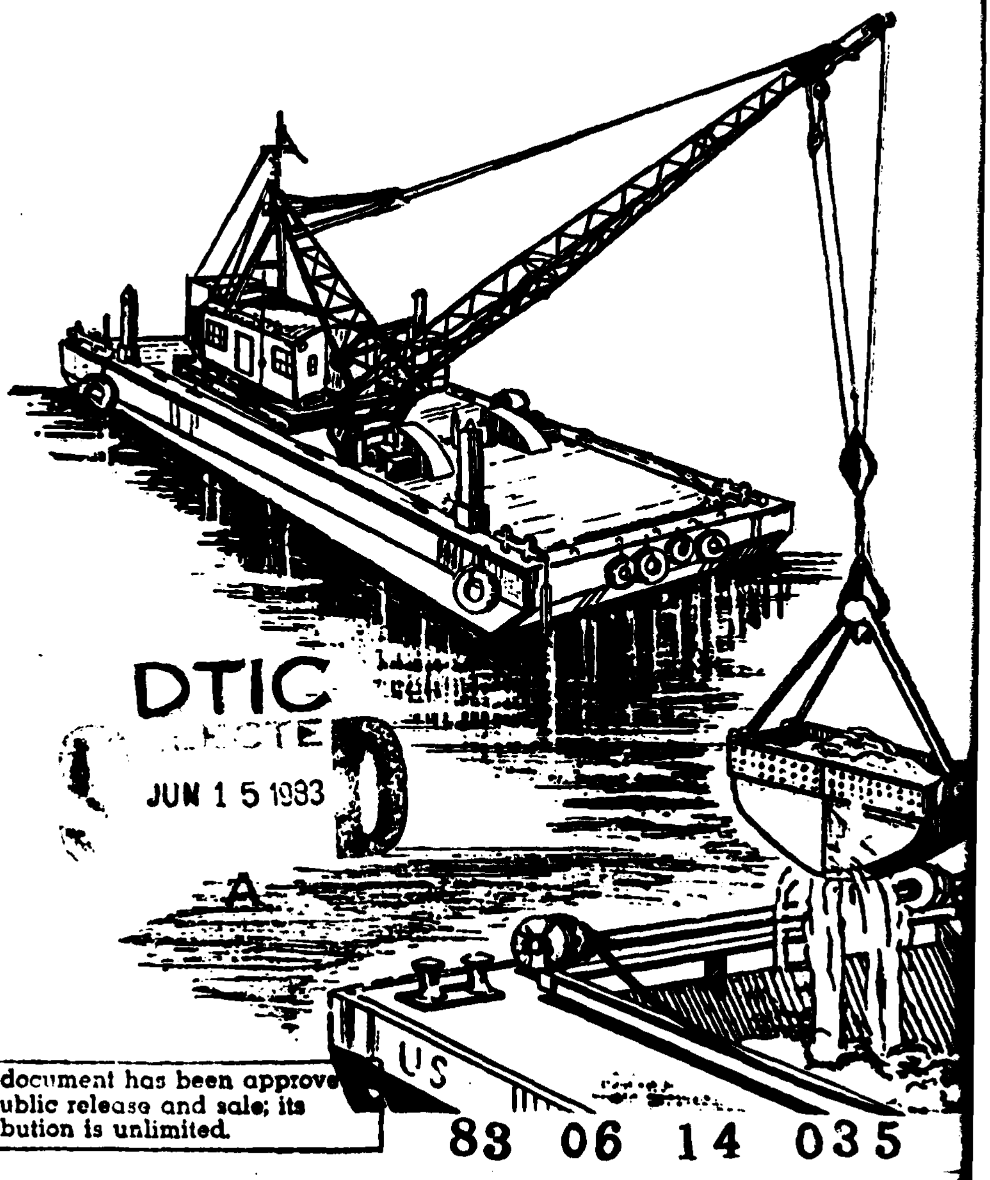
(10)

Erosion and Sedimentation Study
Lorain, Ohio

Volume III

Main Report

AD A129331



US Army Corps
of Engineers
Buffalo District

August 1982

Finalized
March 1983

83 06 14 035

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (*and Subtitle*) Draft Final Feasibility Report, Erosion and Sedimentation Study, Lorain, Ohio-Volume III: Main Report.	5. TYPE OF REPORT & PERIOD COVERED Draft
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE March 1983
	13. NUMBER OF PAGES 50
14. MONITORING AGENCY NAME & ADDRESS (*if different from Controlling Office*)	15. SECURITY CLASS. (*of this report*)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

Approved for public release;distribution unlimited.

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

Lorain Harbor
Erosion
Sedimentation

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

This report documents the result of a study conducted to determine the feasibility of reducing annual maintainance dredging at Lorain Harbor by reducing the sediment from streambank and upland sources. The study was conducted in two parts, one dealing with streambank erosion, the other addressing upland erosion.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

FINAL FEASIBILITY REPORT
LORAIN, OHIO
EROSION AND SEDIMENTATION STUDY

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

TABLES

TABLE OF CONTENTS (CONT'D)

FIGURES

PHOTOGRAPHS

TABLE OF CONTENTS (CONT'D)

ACKNOWLEDGEMENTS

This Feasibility Report was prepared through the efforts of many individuals within the Buffalo District and other agencies. The following are the Corps personnel who were most instrumental in conducting the investigation and preparing the text presented herein.

- Edward Gustek - Study Manager, Western District Branch
- John Zorich - Chief, Western District Branch
- Stephen Yaksich - Chief, Water Quality Section
- John Adams - Chemist, Water Quality Section
- Sophie Baj - Geographer, Water Quality Section
- Fred Boglione - Hydraulic Engineer, Water Quality Section
- James Hassler - Hydraulic Engineer, Hydrologic Investigation Section
- Judith Otto - Geologist, Geotechnical Section
- Steven Predmore - Hydrologist, Hydrologic Investigation Section

Other agencies have contributed to this report through the preparation of supplemental reports. The individuals are numerous and not easily identified. Therefore, recognition is provided by the names of their employing agencies as follows:

- United States Soil Conservation Service
- United States Geological Service
- United States Army Reserve, Cleveland
- U.S. Army Engineer Division, Ohio River Division Laboratory
- U.S. Army Engineer Topographic Laboratory, Ft. Belvoir, VA

The report was produced through the efforts of many other Corps personnel, including the following who contributed significantly to its preparation:

- Roman Bartz - Chief, Drafting Section
- John Acker - Drafting Section
- Donna Davis - Drafting Section
- Paul Ehrnesberger - Drafting Section
- Richard Greene - Drafting Section
- Mary Hamilton - Drafting Section
- Christine Kosinski - Drafting Section
- Irving Stone - Drafting Section
- Freda Soper - Chief, Word Processing Branch
- Lillian Stryczek - Lead Clerk, Word Processing Branch
- Mattie Davis - Word Processing Branch
- Jeanette DeZaiffe - Word Processing Branch
- Mary Ann Schultz - Word Processing Branch
- Diane Szymkowiak - Word Processing Branch
- George Key - Chief, Reprographics Branch
- James Szpakowski - Reprographics Branch

The Buffalo District Engineer during the initial phase of this report was Colonel George P. Johnson and the District Engineer during the final phase was Colonel Robert R. Hardiman. The Chief of the Engineering Division was Donald M. Liddell and the Chief of the Planning Division was Charles E. Gilbert.

Finally, the efforts of other individuals who participated in the study and report preparation, but whose names have not been mentioned above, are gratefully appreciated.

FINAL FEASIBILITY REPORT
LORAIN HARBOR
EROSION AND SEDIMENTATION STUDY

SECTION A - INTRODUCTION

The purpose of this section is to introduce the reader to the Lorain Harbor Erosion and Sedimentation Study and to explain the content and organization of this report. The section presents information on the geographical setting of the study area; the study authority; the purpose of the study; the scope of the study; study participants and coordination; the organization of the report; and prior studies and reports in the area.

GEOGRAPHIC SETTING

The Black River consists of 120 miles of stream, which is comprised of the main stem (15.5 stream miles), the West Branch (46.7 stream miles), the East Branch (44.1 stream miles) and the West Fork (14.4 stream miles).

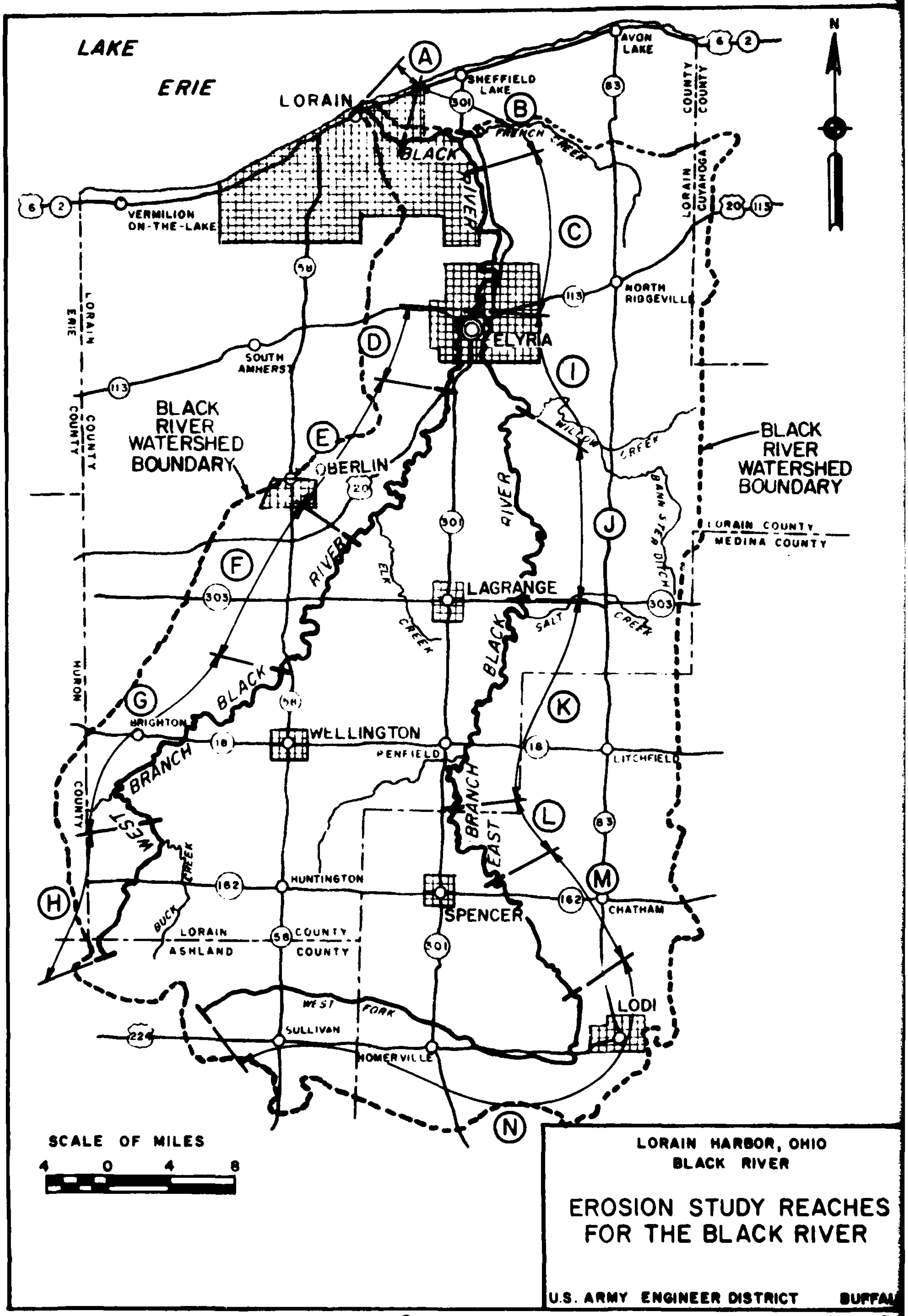
Located primarily in Lorain and Medina Counties, in northcentral Ohio, the Black River Watershed covers 396 square miles as defined by a USGS gaging station at Elyria, OH. Downstream of Elyria, an additional 76 square miles contribute to the river before it empties into Lorain Harbor and the central basin of Lake Erie. Figure 1 shows the general location of the Black River Watershed within the Lake Erie Drainage Basin, in addition to the location of the reaches, population centers, roads and tributaries.

The downstream portion of the Black River Watershed is largely urban, although along the east side of the river in this area there is some agricultural and forest land. The river valley has a north-northwest trend from Elyria, north to French Creek where it breaks sharply to the west for about 2 miles and then enters the lake in a northwest direction.

STUDY AUTHORITY

This study of streambank and upland erosion in the Black River Watershed, OH, is prepared as a portion of the multiobjective planning being done for the Lorain Harbor Feasibility Study. The Lorain Harbor Feasibility Study is being performed under the authority of a 23 September 1976 resolution by the House Committee on Public Works and Transportation, stating:

> "Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report on Lorain Harbor, OH, published in House Document No. 166, 86th Congress, 1st Session, and other pertinent reports, with view of determining whether any modification to the recommendations contained therein is advisable at the present time, including consideration of the passage and safe navigation of new and larger ships operating on the Great Lakes."



LAKE
ERIE
LORAIN
SHEFFIELD LAKE
AVON LAKE
VERMILION ON-THE-LAKE
BLACK RIVER
FRENCH CREEK
LORAIN COUNTY
CUYAHOGA COUNTY
NORTH RIDGEVILLE
ELYRIA
SOUTH AMHERST
LORAIN ERIE
COUNTY COUNTY
BLACK RIVER WATERSHED BOUNDARY
OBERLIN
WILLOW CREEK
BLACK RIVER WATERSHED BOUNDARY
BANNISTER DITCH
LORAIN COUNTY
MEDINA COUNTY
ELK CREEK
LAGRANGE
SALT CREEK
HURON COUNTY
BRIGHTON
BLACK RIVER
WELLINGTON
PENFIELD
LITCHFIELD
WEST BRANCH
EAST BRANCH
BUCK CREEK
HUNTINGTON
SPENCER
CHATHAM
LORAIN COUNTY
ASHLAND COUNTY
WEST FORK
LODI
SULLIVAN
HOMERVILLE
A
B
C
D
E
F
G
H
I
J
K
L
M
N
SCALE OF MILES
4 0 4 8
LORAIN HARBOR, OHIO
BLACK RIVER
EROSION STUDY REACHES
FOR THE BLACK RIVER
U.S. ARMY ENGINEER DISTRICT BUFFAL

FIGURE

Through an intensive public involvement program in 1978, it was determined that the following water resources needs at Lorain Harbor should be addressed and evaluated under this authority.

a. Commercial navigation needs.

b. Recreational navigation needs.

c. Reduction of annual maintenance dredging.

(1) Streambank Erosion Component

(2) Upland Erosion Component

As part of the overall study of the Black River at Lorain, OH, the commercial navigation and the small-boat harbor needs are addressed as separate volumes to the report.

This volume of the Feasibility Report will address only the reduction of annual maintenance dredging.

SCOPE OF STUDY

The primary objective of the Lorain Harbor Erosion and Sedimentation Study is to determine the feasibility of reducing annual maintenance dredging at Lorain Harbor by reducing the sediment from streambank and upland sources. This study was conducted in two parts, one dealing with streambank erosion, the other addressing upland erosion.

The Black River Streambank Erosion portion concentrated on identifying active areas of streambank erosion on the Black River and its tributaries. In addition, this portion concerned itself with estimates of streambank erosion to both the total sediment yield of the watershed and the quantity dredged annually from the navigational channel in Lorain Harbor, OH. Study results that were obtained were utilized to determine the feasibility of undertaking streambank stabilization measures in order to reduce sediment yield from the source.

The Black River Upland Erosion portion of this study concentrated on identifying and estimating the amount of sediment which was produced and delivered to the river from diffuse sources throughout the drainage basin. The method of analysis which was employed utilized the Universal Soil Loss Equation and included information gathered by the Soil Conservation Service field sampling program which was performed in the basin.

These two studies of the Black River were merged in an effort to gather qualitative and quantitative information in order to better define the problems and needs of the Black River Watershed Study Area.

Based on the results of these studies, a determination will be made as to the feasibility of reducing the sediment carried by the river and being deposited in the harbor, and thus reducing the annual maintenance dredging at Lorain Harbor, OH.

STUDY PARTICIPANTS AND COORDINATION

This study is the result of a joint study effort between various Federal agencies through Interagency Agreements with the Buffalo District.

In August 1980, a support agreement was entered into with the U.S. Geological Survey to conduct a 1-year sediment sampling program in the Black River, Ohio Watershed. The purpose of the program is to provide sediment yield data at various locations on the river in order to identify the prolific source areas of sediment within the watershed. The data was coupled with discharge information gathered by USGS in order to define the types of sediment carried by the river system and also the total average annual sediment load (in tons) passing the permanent gage at Elyria, OH.

The Soil Conservation Service (SCS) method of analysis for the Erosion and Sedimentation Study employed the Universal Soil Loss Equation and included information gathered by the Soil Conservation Service field sampling program performed in the basin.

PRIOR STUDIES AND REPORTS

There have been numerous past studies and reports concerning the Lorain Harbor area. The following are the reports which have addressed the problem of erosion and sedimentation:

Reconnaissance Report on Lorain Harbor, U.S. Army Engineer District, Buffalo, September 1978 - This Stage 1 document was prepared by Buffalo District (September 1978, revised January 1979) under the authority of the 23 September 1976 resolution. As a result of the coordination and public involvement during the investigation, it was determined that more detailed studies of commercial navigation, recreational navigation, and maintenance dredging needs should be conducted.

Assessment of Streambank Erosion for Major Streams of the Buffalo District, U.S. Army Engineer District, Buffalo, August 1977 - This report summarizes the results of a preliminary assessment of streambank erosion occurring on the major streams and rivers within the Buffalo District. The report provides information on the general characteristics, sediment transport, and location and extent of streambank erosion.

SECTION B - PROBLEM IDENTIFICATION

EXISTING CONDITIONS

The purpose of this section is to inform the reader of this report of the water and related resource problems and needs, or lack thereof, in the study area and for which this study seeks a solution. The section presents information on the existing conditions in the general area; discusses the need for identifying and quantifying the sources of sediment throughout the study area (from streambank and upland erosion) and reviews the planning constraints under which this study was conducted; discusses the specific planning objectives of the study; and reviews the conditions that would exist if no Federal action was taken.

Location of Study Area

The Black River flows northerly for about 120 miles through parts of Lorain, Medina, Ashland, Huron, and Cuyahoga Counties. This includes the communities of Lorain, Elyria, Oberlin, Grafton, and Wellington. Lodi is located at the extreme southeast portion of the basin. Lorain is at the mouth of the river where it flows into Lake Erie. Upstream, the main channel (15.5 miles) divides at Elyria into its East (58.5 miles) and West (46.7) Branches (see Appendix A for Basin Maps). The greatest concentration of the population is in the metropolitan area of Elyria and Lorain.

Physiography

The Black River Watershed lies within the physiographic provinces of the Allegany Plateau and the Erie/Ontario lowland. The area of the drainage basin is approximately 467 square miles, about 1 percent of the entire State. As it flows over the Allegany Plateau, it incises a steep-walled bedrock valley. This area of the basin has a hilly topography. The lower reaches from Elyria to the mouth flow over the flat lake plain, crossing some low sandy beach ridges. The sinuosity, meander scars, and oxbow lakes which occur in both East and West Branches are indications that the channels have been migrating through time. Elevations of the basin range from 570 feet above sea level at the mouth to about 1,130 feet above sea level at the head waters. The average stream gradient of the Black River is 7.6 feet per mile. The East Branch has an average gradient of 9.0 feet per mile and the West Branch 9.9 feet per mile.

Bedrock Geology

The bedrock of the study area is part of a geologic structure known as the Cincinnati Arch. The local bedrock from Elyria downstream is composed of Cleveland Shale of Devonian Age. This is a blueish to brownish black shale which turns coffee colored upon weathering. It is compact and massive, however weathered, it becomes fissile and brittle. Pyrite deposits occur along laminae. Upstream from Elyria, the bedrock is Mississippian Age. Members included in this area are the Bedford and Maxville Formations. The Bedford Shale is a grayish to dusky red shale with abundant gray shale,

sandstone or siltstone lenses. It ranges in thickness from 30 to 80 feet. The Maxville is a hard limestone containing some shale. It ranges in thickness from 0 to 200 feet.

Surficial Geology

The surficial geology of the Black River drainage basin is a result of Pleistocene glaciation. The lacustrine deposits in the lowest reaches of the stream are silt and clay, ranging in thickness from 5 to 50 feet. They are commonly laminated and underlain by till. The morainal deposits which cover the majority of the upper basin are composed of an unstratified, unsorted mixture of clay, silty sand, and some coarser fragments. This till ranges in thickness from 25 to 50 feet. In the upstream reaches of the Black River, belts of sharply rolling hummocky terrain are produced by end moraines. These are composed of unsorted, unstratified mixtures of sand, silt, clay, and some gravel, often as much as 100 feet thick.

The sediments immediately adjacent to the stream are listed below. Beach ridges are composed of sand and gravel. The northern reaches of the drainage basin are composed of light colored, poorly drained lake bed silty loams. The East and West Branch stream channels have moderately well-drained acid soils composed of silt loam and clay loams. The remaining drainage basin is composed of silt loams, sandy loams, and silty clay loams.

Economic Geology

In northernmost and northcentral Ohio, sand and gravel operations are a lucrative business. The largest suppliers of these materials are in glacial deposits. Typically, they are composed of feldspar, quartz, garnet, and magnetite. Also, there are fragments of granite, gneiss, schist, and diorite limestone. Lake sand is another source of sand, however, the extent is limited to areas near the coast of Lake Erie. Sands are also obtained from rivers, flood plains, and deltas of the area. Crushed bedrock provides another source of sand.

Devonian and Mississippian shales of the region are used for the production of brick and tile. Rock quarries also provide high quality grinding and building stones.

Natural gas and oil are two other resources which are found in abundance in parts of Ohio.

The rock salt beds of Ohio are part of the Salina formation. This is one of Ohio's most important abundant economic minerals. Approximately 9,100 square miles of the eastern and northeastern part of the State are underlain by this salt bearing Salina formation.

Climate

The climate of Lorain can be described as humid and temperate. The climate in the region is characterized by large annual and daily temperature ranges, although the presence of lake Erie tends to moderate these temperature

changes. The average January temperature is 27.7°F and July temperture is 72.9°F. The highest temperature recorded is 105°F and the lowest is -23°F.

Cold air masses move down from Canada during the winter months but are modified by the relatively warm waters of Lake Erie, resulting in cloudiness and frequent snow from November through March.

Precipitation is well distributed throughout the year. The annual average precipitation is 35 inches, with about 17 inches occurring as rainfall during the growing season.

Water Quality

The U.S. Environmental Protection Agency (EPA) conducted numerous water quality surveys in the Black River Basin from 1972 to 1979. An intensive survey of the lower Black River was completed from 16-19 July 1979 and included most of the sampling points employed in the 23-26 July 1974 intensive surveys. Since there were no significant differences in waste treatment at the Elyria Sewage Treatment Plant (STP) and U.S. Steel, the stream quality data obtained in 1979 are quite similar to those obtained in 1974. The data from this survey demonstrated the significant increase in stream temperature caused by the U.S. Steel-Lorain Works and highlighted the impact of the Elyria STP and U.S. Steel discharges on dissolved oxygen levels in the lower river. Concentrations as low as 2 to 3 milligrams per liter were recorded despite a river flow of 168 cfs. Problems with ammonia, cyanide, and phenolics were also noted in the river. A total cyanide concentration of 230 ug/l was recorded near U.S. Steel while the present water quality standard is 25 ug/l. Relatively high levels of metals were also detected. An intrusion of lake water into the Black River was demonstrated.

States are required to classify streams or segments of streams as either "water quality" or "effluent" limiting. Effluent limiting segments are those where applicable water quality standards are being met, or there is certainty that these standards will be achieved by application of effluent limitations. Water quality limiting segments are those where standards are not being achieved and where application of the above treatment levels is not sufficient to achieve water quality standards. The Black River main stem from the mouth of the confluence of the East and West Branches has been classified as water quality limiting. (Source: Black River Water Load Allocation Report, prepared by U.S. Environmental Protection Agency, 1980).

Sediment Quality

Sediment testing in Lorain Harbor was conducted by the U.S. Environmental Protection Agency (USEPA) in 1975 and by the Buffalo District COE in November 1981. The results of these tests are shown in Tables 1 and 2, while Figure 2 shows the locations at which sediment samples were taken.

Based on USEPA's 1975 testing, that portion of the harbor that is shaded on Figure 2 has been determined to be polluted and therefore unacceptable for

Table 1 - Sediment Pollution Evaluation

Harbor: Lorain

State: Ohio

Sampled: 25 February 1975

Evaluation Parameter	Guideline Values	Value at Each Station as a Percent of Dry Weight									
		LOR-6	LOR-8	LOR-9	LOR-10	LOR-11	LOR-12	LOR-13	LOR-15	LOR-16	LOR-17
Volatile Solids	6.0	7.43	6.77	6.29	5.33	8.12	4.37	8.53	8.78	9.07	9.94
Chem. Oxy. Demand	5.0	8.50	8.40	9.10	4.80	11.60	6.20	12.10	14.50	13.00	15.00
T. Kjel Nitrogen	0.10	0.2700	0.2200	0.1800	0.1600	0.2500	0.1200	0.3200	0.3300	0.2400	0.3000
Oil - Grease	0.15	0.3000	0.4500	0.2800	0.1700	0.8400	0.1800	0.9000	0.9700	1.5000	2.3000
Mercury	0.0001	0.00001	0.00001	0.00002	0.00001	0.00002	0.00001	0.00003	0.00003	0.00004	0.00003
Lead	0.005	0.0062	0.0079	0.0069	0.0044	0.0120	0.0056	0.0164	0.0160	0.0216	0.0177
Zinc	0.005	0.0415	0.0470	0.0460	0.0360	0.0700	0.0370	0.0770	0.0900	0.1230	0.0980
Supplementary:											
T. Phosphorus		0.0930	0.1300	0.1100	0.1000	0.1500	0.0950	0.2500	0.2300	0.2200	0.1900
Ammonia Nitrogen		0.0240	0.0280	0.0230	0.0200	0.0400	0.0120	0.0670	0.0340	0.0240	0.0310
Cyanide		0.000091	0.00031	0.000038	0.000056	0.00037	0.000066	0.0005	0.00023	0.00056	0.00177
Manganese		0.0840	0.0800	0.0740	0.0710	0.0860	0.0625	0.0885	0.0780	0.1010	0.1105
Nickel		0.0040	0.0035	0.0055	0.0060	0.0070	0.0050	0.0065	0.0085	0.0100	0.0075
Arsenic		0.0013	0.0016	0.0013	0.0012	0.0013	0.0013	0.0011	0.0016	0.0019	0.0015
Barium		0.0073	0.0070	0.0051	0.0052	0.0091	0.0042	0.0143	0.0125	0.0113	0.0034
Cadmium		0.00025	0.00077	0.00042	0.00058	0.0015	0.00046	0.0016	0.0018	0.0029	0.0023
Chromium		0.0061	0.0076	0.0064	0.0059	0.0125	0.0060	0.0126	0.0134	0.0182	0.0146
Magnesium		0.8200	0.7800	0.8300	0.8000	0.1200	0.7000	0.7100	0.5000	0.5900	0.5300
Copper		0.0133	0.0112	0.0117	0.0114	0.0182	0.0124	0.0325	0.0165	0.0268	0.0225
Iron		4.0800	4.0900	4.0700	4.1700	4.7600	3.2500	4.8100	4.7100	6.5500	6.0400

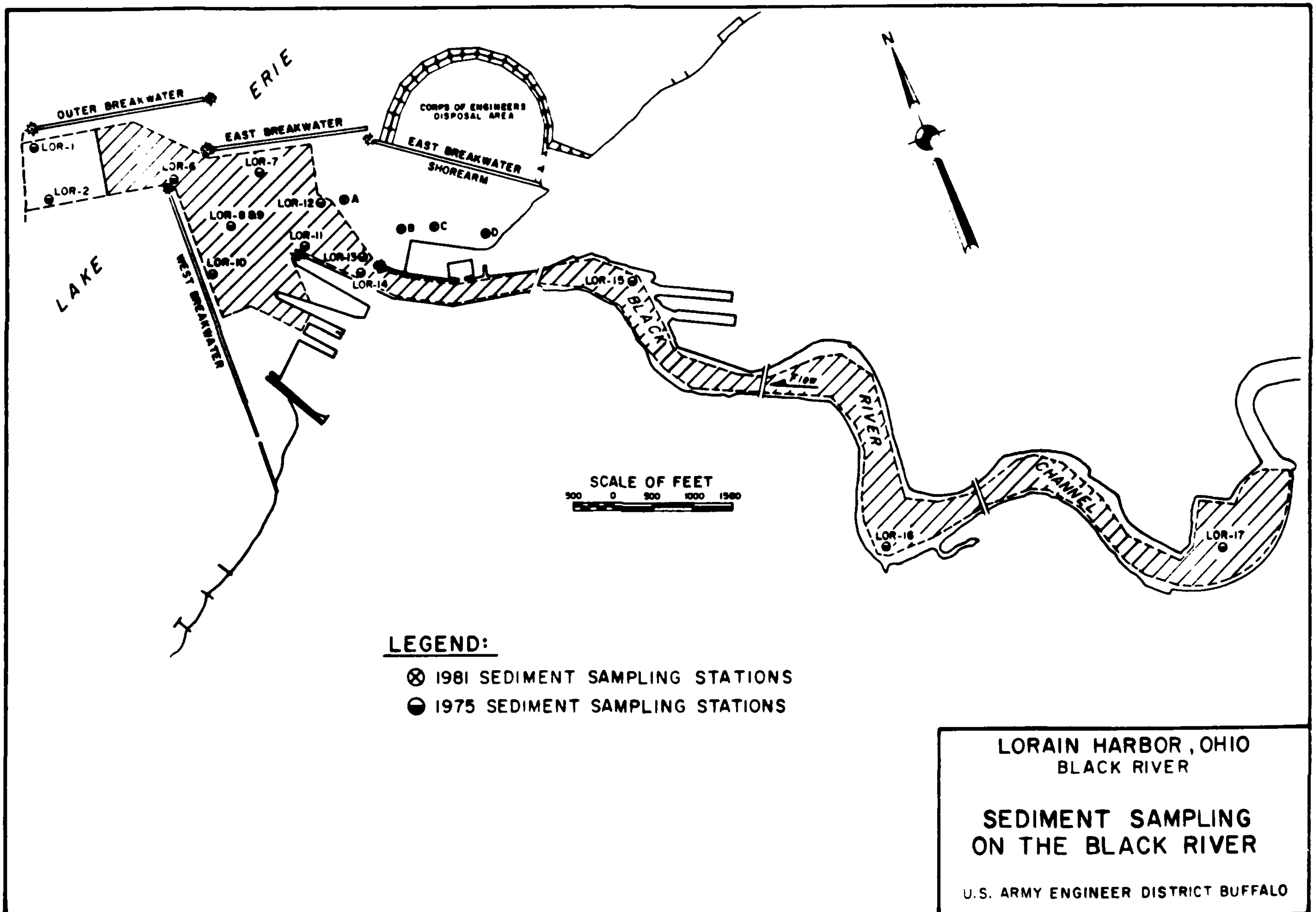
Table 2 - Sediment Pollution Evaluation Inside East Breakwater, November 1981

Parameter	EPA Region 5 Criteria: Nonpolluted	EPA Region 5 Criteria: Moderately Polluted	EPA Region 5 Criteria: Heavily Polluted	Stations: A	Stations: B	Stations: C	Stations: D
Volatile Solids(%)	<5	5-8	>8	3.52	2.42*	2.82	1.70
Ammonia (mg/Kg)	<75	75-200	>200	13.0	18.85*	12.1	10.9
COD (mg/Kg)	<40,000	40,000-80,000	>80,000	46,800	29,400*	27,300	85,300
Phenols (mg/Kg)	-	-	-	2.3	8.2*	1.1	<0.25
Cyanide (mg/Kg)	<0.10	0.10-0.25	>0.25	<0.60	<0.62*	<0.60	<0.49
Phosphorus (mg/Kg)	<420	420-650	>650	878	768.5*	1,530	766
Oil & Grease (mg/Kg)	<1,000	1,000-2,000	>2,000	1,411	811.5*	1,020	472
Total Kjeldahl Nitrogen (mg/Kg)	<1,000	1,000-2,000	>2,000	3,190	1,045.5*	20,660	15,290
Arsenic (mg/Kg)	<3	3-8	>8	15*	13	17	12
Cadmium (mg/Kg)	-	-	>6	5.8*	2.8	5.1	36
Chromium (mg/Kg)	<25	24-75	>75	38*	24	33	16
Copper (mg/Kg)	<25	25-50	>50	51*	29	43	23
Iron (mg/Kg)	<17,000	17,000-25,000	>25,000	44,000*	21,000	44,000	34,000
Lead (mg/Kg)	<40	40-60	>60	32*	27	48	25
Manganese (mg/Kg)	<300	300-500	>500	630*	460	720	500
Mercury (mg/Kg)	-	$\geq$1**	$\geq$1**	0.13*	0.044	0.11	0.058
Nickel (mg/Kg)	<20	20-50	>50	39*	30	41	22
Zinc (mg/Kg)	<90	90-200	>200	195*	200	250	160

*Mean of two replicate analysis.

**USEPA has only established one guideline value for mercury - "Polluted."

(Testing conducted by EG&G Bionomics, Wareham, MA, under contract by Buffalo District, COE, 1981.)


LORAIN HARBOR, OHIO
BLACK RIVER
SEDIMENT SAMPLING
ON THE BLACK RIVER
U.S. ARMY ENGINEER DISTRICT BUFFALO
LEGEND:
1981 SEDIMENT SAMPLING STATIONS
1975 SEDIMENT SAMPLING STATIONS
SCALE OF FEET
500 0 500 1000 1500
N
LAKE
ERIE
OUTER BREAKWATER
EAST BREAKWATER
WEST BREAKWATER
EAST BREAKWATER SHOREARM
CORPS OF ENGINEERS DISPOSAL AREA
LOR-1
LOR-2
LOR-6
LOR-7
LOR-8 & 9
LOR-10
LOR-11
LOR-12
LOR-13
LOR-14
LOR-15
LOR-16
LOR-17
A
B
C
D
BLACK
RIVER
CHANNEL
FLOW

FIGURE

open-water disposal. These polluted dredgings are placed in the diked disposal area adjacent to the Lorain Harbor East Breakwater Shorearm. Dredgings from the remaining portion of the harbor that were tested in 1975 may be disposed of at the designated open-lake site. This decision, made by USEPA, was based on chemical and biological data as well as field observations. All sites tested by the Buffalo District COE, inside the East Breakwater in 1981 indicate the sediments are highly polluted for cyanide, phosphorus and arsenic. Some sites are highly polluted for COD, TKN, copper, iron, manganese and zinc. Some sites are moderately polluted for COD, oil and grease, TKN, chromium, copper, iron, lead, manganese, nickel and zinc. No significant concentrations of organic compounds, including mirex, DDT, and PCB's were detected at any of the sites sampled in 1981.

Pollutant Export

Pollutant export data on Lorain Harbor was obtained from the Lake Erie Wastewater Management Study Methodology Report, 1979.

Table 3 shows the mean annual pollutant concentrations for the Black River at the sampling station at Elyria, OH. Also shown are the concentrations measured in the Maumee, Cuyahoga and Grand Rivers in Ohio. Parameters shown in Table 3 are total phosphorus, dissolved orthophosphate, nitrite-nitrate nitrogen, ammonia nitrogen, total kjeldahl nitrogen, suspended solids, chlorides and silica.

Table 3 shows the comparison of the Black River Basin to the Maumee, Cuyahoga and Grand River Basins, all which have watersheds with different land use patterns.

The Black River Basin has agricultural land use in the upper watershed and industrial and urban land use near the mouth. These land use patterns reflect the water quality of the basin as shown in Table 3. The Black River has total phosphorus, nitrite-nitrogen, suspended solids and chloride concentrations similar to the Maumee River which is agricultural. It has orthophosphate and ammonia nitrogren concentrations similar to the Cuyahoga which has large amounts of urban and industrial land use. All three rivers have poorer water quality than the Grand River which has more than one-half of the watershed in pasture and forest.

Natural Environment

Biological Environment - This section presents a brief summary of the biological environment and dominant species present in the Lorain Harbor study area. This information has been summarized from that provided in the U.S. Fish and Wildlife Service Intermediate Fish and Wildlife Coordination Act Report. This report, dated 22 January 1981, contains data from a four-season biological survey conducted by Fish and Wildlife Service personnel from October 1978 to October 1979. The U.S. Fish and Wildlife Service conducted various biological surveys, literature searches, and contacted professionals with knowledge of the Lorain Harbor area. The Fish and Wildlife study area included the outer harbor, the lower Black River, and riparian areas to 3 miles upstream of the upper turning basin.

Table 3 - Mean Annual Pollutant Concentrations (mg/l)

Basin	Total Phosphorus as P	Ortho Phosphorus as P	Nitrite-Nitrate Nitrogen as N	Ammonia Nitrogen as N	TKN as N	Suspended Solids	Chloride as C	Silica as SiO_2	Mean Annual Flow
Black River	0.457	0.204	3.000	0.715	4.120	285.0	34.40	4.65	318.00
Maumee River	0.430	0.089	4.440	0.163	1.70	217.0	30.6	6.29	4,786.0
Cuyahoga River	0.429	0.204	1.845	0.375	1.390	152.0	92.50	6.50	789.00
Grand River	0.074	0.022	0.301	0.021	-	53.0	15.89	2.55	782.00

Habitat - The number and nature of biological habitats present in the study area are very limited due to the improvements that have been made to Lorain Harbor for commercial navigation. The outer harbor is dominated by deep-dredged channels and rubblemound and sheet pile breakwaters. The lower 3 miles of the Black River (inner harbor) has also been deep-dredged for commercial navigation. From the river mouth to the Erie Avenue Bridge much of the riverbanks have been bulkheaded. The rest of the inner harbor has steep, eroding banks. The only biological habitat of significant importance is a wetland, about 15 acres in size, located on the Black River just downstream of the 21st Street Bridge. This wetland is vegetatively dominated by broad-leaved cattails and other emergent plants. Water quality in the lower reaches of the Black River is severely degraded and sediments from both the inner harbor and outer harbor are polluted. The combination of lack of available habitat and poor sediment and water quality severely limit the establishment of high quality habitats and species associations in the study area.

Fishery Resources - Within the last 10 years, 47 species of fish have been identified for the outer harbor area. During the same period of time, 41 species of fish have been collected within the lower reaches of the Black River. Gizzard Shad and Emerald shiner dominate catches in both the outer harbor and the lower river area. Freshwater drum and smelt are also common in the outer harbor. Sport fishing is almost completely confined to the outer harbor area. The most common game fish caught are yellow perch, smallmouth bass, and channel catfish. Spawning and nursery habitat for fish are almost nonexistent in the lower river area and severely limited, due to deep depths in the outer harbor.

Birds - Lorain Harbor is located on the eastern edge of the Mississippi flyway and on the western edge of the Atlantic flyway, thus attracting large numbers of ducks, geese, and swans which pass through the area on migratory flights between southern wintering grounds and northern breeding grounds. The outer harbor provides good feeding habitat for many species of diving ducks including mergansers and scaup. These ducks are primarily attracted to the abundant food source of gizzard shad and emerald shiners. The only abundant dabbling duck is the mallard. No significant amounts of waterfowl breeding occur in either the outer harbor or the lower reaches of the Black River.

PROBLEMS AND NEEDS

General

Erosion and sedimentation problems are a concern to residents of the Black River Watershed area. Erosion of stream channels and land surfaces feeds large quantities of sediments to the river where it impairs water quality, aggravates flooding problems, depresses oxygen levels, and alters aquatic life.

Increased erosion rates are mainly a result of man-made disturbances such as highways and building construction activities, surface mining operations, and cropping and timbering practices which remove the protective vegetative cover. Photographs 1 through 4 illustrate examples of these problems.

Photo 1 - West Branch Black River near Griggs Road,
Rochester, OH., COE, August 1981.
Debris-laden waters near woodland.

Photo 2 - East Branch Black River near Spencer, OH.
COE, August 1981.
Bank erosion next to woodland.

Photo 3 - East Branch Black River near Spencer, OH.
COE, August 1981.
Bank erosion and debris near woodland.

Photo 4 - West Branch Black River near Route 58 between
Wellington and Pittsfield, OH. COE, August 1981.
Bank erosion next to woodland.

A study concerning the erosion and sedimentation problems was conducted to determine the major contributor of sediments in the harbor, and also to determine whether annual maintenance dredging, which is done periodically in the Lorain Harbor by the Corps of Engineers, could be reduced.

The Corps of Engineers is responsible for repairing the breakwaters and for dredging the river channels and lakefront harbor to authorized depths.

Corps of Engineers derrickboats are currently used to maintain the breakwaters. Repairs to the East and West Breakwater include periodic rearrangement of the existing armor stone and additions of new armor or core stone where required.

Corps of Engineers hopper-type dredges are used to maintain authorized depths within the Federal project limits. This dredging is normally performed during a 2 to 4-week period between April and June. Polluted material dredged since 1978 has been deposited in a confined disposal area adjacent to the East Breakwater Shorearm.

Harbor Maintenance Dredging - The Federal project at Lorain Harbor is dredged periodically by hopper-type dredges. Historical quantities removed during these operations are summarized in Table 4 for the period 1967 through 1981. The average annual volume dredged has been approximately 144,000 cy and is normally performed during a 2- to 4-week period between April and June. The average annual volume dredged is based on dry weights of sediment as opposed to saturated weights. The average dry weight of sediment dredged from Lorain Harbor is in the proximity of 70 lbs/cf.

Therefore, 144,000 cy is synonymous with 136,000 tons.

(144,000 cy X 27 cf/cy X 70 lbs/cf $\div$ 2,000 lbs/ton)

Occasionally, dredging operations have extended into November. A confined disposal area adjacent to the East Breakwater shorearm was completed in 1978 to contain polluted dredged material. This structure has an estimated capacity equivalent to 10 years of normal dredging activity. This design standard is based on the assumption that after 10 years water treatment plants located upstream will help upgrade the quality of existing bottom sediments. In addition, implementation of land conservation measures will reduce the quantity and/or increase the quality of sediments within Federal channels to an acceptable level which will permit the resumption of open-lake and/or shore area dumping.

At the Initial Public Meeting held on 31 May 1978, the commercial navigation interests reiterated their needs and concerns as expressed at the earlier Orientation Workshop meeting conducted on 27 April 1978. Interested citizens and local officials restated their desires for expanded recreation boating and fishing facilities. The U.S. Fish and Wildlife Service stated their opposition to any project work which would diminish or adversely alter any existing marsh or wetland areas thereby adversely impacting wildlife habitat.

Table 4 - Summary of Historical Dredging at Lorain, OH

Year	Cubic Yards	Year	Cubic Yards
1967	106,713	1974	498,586
1968	230,357	1975	134,986
1969	142,456	1976	42,290
1970	189,414	1977	30,420
1971	136,021	1979	192,048
1972	143,598	1980	96,194
1973	83,922	1981	132,844
		Total	2,159,849
		Average Annual	144,000

Based on these meetings and communications, the improvements desired by local interests are summarized as follows:

a. Improvements to the lakefront harbor entrance to permit safe navigation of the harbor for the new larger vessels.

b. Improvements to the Erie Avenue Bridge to permit launching of American Shipbuilding Co. 1,000-foot vessels without the use of tugs.

c. Improvements to the Black River channel for safe navigation and to accommodate larger vessels or lakefront construction of a transshipment facility with alternative modes of transportation (conveyor, special purpose vessel, rail, or truck) for the upriver movement of ore and stone which will permit the utilization of larger more economical vessels at Lorain Harbor.

d. Adequate provision for future protected small-boat berthing facilities and consideration of the use of the protected harbor area by recreational craft.

e. Improvement in water quality in the Black River, i.e., reduction in turbidity and sediment in the river.

PLANNING OBJECTIVES

Planning Constraints

Several planning constraints were identified which impacted on the conduct of the study and the formulation of alternative plans developed to control

erosion in the study area. These planning constraints include the following: (a) environmental; (b) Corps of Engineers policy; (c) state-of-the-art techniques in predicting sheet erosion (erosion of the surface of the land). These constraints are reviewed below.

a. Environmental Constraints - All plans of improvement should avoid or minimize objectionable or adverse impacts to aquatic or terrestrial habitat and maximize environmental benefits prior to, during, and following construction. A plan should avoid or minimize water pollution and aesthetically objectionable features. Adherence to this principle will result in speedy public and agency acceptance of the recommended plan of improvement.

Throughout the planning effort, vegetation was the preferred treatment method in controlling erosion. Economics also dictated that vegetation be utilized as much as possible since its costs was less than other types of land treatment (terracing, grade control structures, subsurface drainage, etc.) and streambank stabilization techniques (riprap, gabions, etc). Where the erosion forces were too great to be controlled by vegetation, such as at sharp bends in the river and on long, steep slopes, other types of structural measures were specified. These structural measures were kept to a minimum not only to preserve the existing environment, but to reduce the cost of the alternatives that were formulated.

b. Corps of Engineers Policy - The purposes of this study are to determine the prolific sources of sediment throughout the study area (from land and streambank erosion) and identify methods of controlling erosion and sedimentation through structural and nonstructural means. Implementation (construction) of plans to control streambank erosion will be pursued by the Corps of Engineers under the existing study authority as this authority provides for implementation as well as investigation. Implementation of measures to control erosion in the upland area must, however, be pursued by other interests. The Corps can, however, offer technical assistance and encouragement to local interests who desire to implement land management programs to control erosion. In addition, a series of general management programs will be developed in this report to inform local interests as to the types of treatment measures that would be required to control erosion in the upland area.

c. State-of-the-Art Techniques in Predicting Upland Erosion - As discussed in Section C of the Main Report, the Universal Soil Loss Equation (USLE) was used by the Soil Conservation Service to predict sheet erosion that is occurring on the surface of the land within the study area. The USLE is an empirical formula developed at the Agricultural Research Service - U.S. Department of Agriculture, that groups the numerous interrelated physical and management parameters that influence the rate of erosion into six major factors that can be expressed numerically. Selection of specific numerical values for these six factors are determined at the particular site under study. Although research has supplied information from which at least approximate values may be obtained, selection of these values relies on a subjective evaluation of the physical conditions of the site under study by field personnel. There are also numerous reservations regarding the use of this equation for large basin studies since the formula was initially

developed to predict soil loss from specific farm fields and other small land areas. In addition, while the USLE estimates the quantity of soil loss from the area under study, it does not predict the delivery of this soil to the receiving stream. In spite of these limitations and the possibility of erroneous results, the equation is recognized as the most reliable method of quantifying potential soil movement that is currently available.

National Objectives

The Water Resources Council's (WRC) Principles and Guidelines (P&G) direct that the Federal objective of water and related land resources planning is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. These contributions are measured as the direct net benefits that accrue in the planning area and the rest of the nation.

Specific Planning Objectives

Specific planning objectives are the National, State, and local water and related land resources management needs (opportunities and problems) specific to a study area that can be addressed to enhance National Economic Development and Environmental Quality. Based on a review of the directives established by the authorizing resolutions, previous reports for the area, statements by individuals in the private sector, input from officials at many levels of Government, and an analysis of the problems and needs of the study area, as discussed previously, the specific planning objectives for the Lorain Harbor Erosion and Sedimentation Study that have been identified are as follows:

a. Local interests have expressed a need for identifying and quantifying sources of erosion in the Black River Basin. Identification of sources of erosion is also required before effective erosion control practices can be formulated and constructed. Therefore, the first objective of this study is to identify and quantify the significant sources of erosion in the 472 square mile watershed.

b. Erosion and sedimentation is a serious problem in the Black River Basin. Dredging the navigation channels and lakefront harbor at Lorain, OH, is an expensive annual expenditure for the Corps of Engineers. In addition,

because the sediment dredged is heavily polluted, it requires expensive diked disposal in lieu of traditional open lake dumping. The Lake Erie Wastewater Management Study has identified phosphorus, which is transported in part by eroding soil particles to Lake Erie, as the major cause of degradation of Lake Erie. Navigation interests have also stated that sediment accumulation in Lorain Harbor interferes with their use of the harbor facilities and increases the delivery cost of the cargo shipped. Therefore, one objective of this study will be to formulate and implement a plan to control streambank erosion and to develop a general management program that informs local interests of the types of measures that would be required to control sheet erosion in the upland area and the magnitude of the costs involved.

c. Any development that adversely impacts on the existing fish and wildlife habitat in the study area poses severe environmental concerns. Therefore, one objective of this study will be to minimize or eliminate any adverse environmental impacts resulting from this project on the existing fish and wildlife habitat. This objective could be met, for example, by employing nonstructural means (vegetation) wherever feasible.

d. The maintenance of national strength and satisfactory levels of living will be achieved by increased national income and productivity. Therefore, one objective of this study will be to maintain or improve the economic status of the area. This objective will be met by implementing a plan for which the benefits derived from the project exceed the project costs.

Conditions If No Federal Action Taken

In any formulation, there is always the basic question of "is there a justified need for change?" Therefore, the conditions that would exist if no Federal action were taken to control streambank erosion were investigated for this study. (As previously stated, although general management programs to control sheet erosion in the upland area will be developed in this report, Corps of Engineers policy prohibits active participation in implementing these plans.) Rather, the Corps will look to local interests to implement these plans. Besides answering the basic question, these conditions will also provide a common basis for comparing alternative plans of improvement as discussed in Section C of the Main Report.

As a result of no action, streambank erosion will continue to adversely impact on residents of the Black River Basin, the Federal Government, and users of Lorain Harbor. Sediment introduced into the river from streambank erosion will continue to settle out and form shoals in the navigation channel and lakefront harbor at Lorain. These shoals will have to be removed by expensive maintenance dredging. In addition, since the sediment dredged from Lorain Harbor is classified as heavily polluted, it will require diked disposal. Navigation interests will also be inconvenienced when using the harbor facilities as they maneuver around the dredging equipment and are forced to lighter due to reduced channel depth before dredging operations are completed.

If no Federal action were taken, the existing environment would not be disturbed. However, since sediment carried by the river adversely affects aquatic life, this would not be a completely desirable situation.

SECTION C - RESULTS OF THE EROSION AND SEDIMENTATION STUDY

This section presents results of the erosion and sedimentation study on Lorain Harbor. For the purpose of this report, the study area has been subdivided into two components, the streambank erosion component and the upland erosion component.

The streambank erosion component will begin with a general introduction; streambank erosion methodology; results of the study conducted to quantify the amount of sediment produced, and finally streambank treatment measures to control erosion.

The upland component will discuss upland erosion methodology, existing Potential Gross Erosion (PGE), and potential reduction of upland erosion. In conclusion of Section C, the two components (streambank and upland) will be analyzed in regards to sediment export and delivery of eroded materials.

Details of these studies, including detailed descriptions of the methodologies used to identify and quantify the sources of sediment for each component and the results of the studies conducted, are presented in the Appendices. The reader is encouraged to review these appendices in order to gain a full understanding of the erosion and sedimentation problems that exist in the basin.

STREAMBANK EROSION COMPONENT

General

The streambank erosion component consists of a determination of the quantities of erosion from the Main Stem, East Branch, West Branch, and the West Fork.

Methodology

The field survey work utilized the USDA Soil Conservation Service Standard method of stream bank erosion estimation. In this method, estimates of long-term rates of streambank erosion are made through the observation of various features which typify erosion. Such parameters as the soil type, age and condition of exposed tree roots, fallen trees, tilt of trees, exposure of pebbles or cobbles embedded in the bank material, establishment of vegetation, and obvious signs of rapid recession such as mass wasting or slumping of banks are among the many characteristics available to the observer to make a reasonable estimate of streambank erosion.

In a study conducted in 1977 by the Buffalo District entitled "Assessment of Streambank Erosion for Major Streams of the Buffalo District," reaches of the Black River were subdivided and identified according to morphologic similarities. In addition, the rate of streambank erosion occurring along the banks of the Black River was estimated. Utilizing the information obtained from this Buffalo District Study, a sampling procedure was established whereby the reaches exhibiting the greatest amount of erosion

would be sampled more thoroughly than those exhibiting low erosion, while those reaches exhibiting minimal or no erosion would not be sampled.

The field survey employed this stratified sampling procedure in obtaining measurements of bank height, erosion length and recession/deposition rate among other parameters. Once the above data were collected for the entire streambank erosion component area, the volume of annual streambank erosion and deposition were calculated.

The actual volumes of streambank erosion and deposition were then extrapolated to cover the extent of each reach, and subsequently the length of the entire Black River. These extrapolated values of volume of sediment eroded and deposited served as a basis for the entire streambank erosion study.

An attempt was made by the District to utilize photo interpretation to estimate rates of streambank erosion. Aerial imagery from flights in 1938, 1951, and 1979 were obtained for the purpose of estimating the rate of recession of streambanks on the main stem, east branch, west fork of the east branch and the west branch of the Black River. The 1938 photography was obtained from the National Archives and Records Service. The 1951 and 1979 imagery were obtained from the United States Department of Agriculture, Agricultural Stabilization and Conservation Service. The USGS 7-1/2-inch topographic maps completed in the early 1960's were used as base maps.

The objective in the use of the aerial photography was to measure changes in the location of the channel over the 41-year span. However, a variety of factors combined to made careful measurements of recession rates impossible. The 1938 imagery was not of the highest quality, and because of its age, perhaps was not as clear as it once was. The 1951 photos are excellent. Between 1951 and 1979, the USDA has modified the specifications for acquisition of photography. In the early 1970's their program was changed to acquire imagery at a scale of 1:40,000 rather than the previous scale of 1:20,000. Imagery is now obtained at the same altitude as before, but with a 6-inch lens instead of a 12-inch lens. The resulting photos are not of the same quality as before, and are considerably more distorted as a result of the use of the side angle lens.

Measurement of features on the surface from this uncontrolled photography is virtually impossible. Even large recession rates, for example 0.5 ft/yr, would displace the channel location on the photos by only a little more than 0.01 inches.

The photography was used, however, to assess major changes in the channel. Meander breakthroughs are easily documented by this technique.

Streambank Erosion Survey and Meander Changes

Sediment produced from streambank erosion was classified as either annual streambank erosion or meander changes. Annual streambank erosion is the average amount of soil loss from the banks of a stream in one year. Meander changes are areas where the stream changes its course during a major runoff

event. The results of the studies conducted for each category are discussed below.

Streambank Erosion Survey

Results of the streambank erosion survey indicate that of 97 miles of streambank studied, 11 miles were actively eroding. The location of these streambanks is shown on Plates 1-8 in Appendix A.

Table 5, Typical Streambank Characteristics by Reach, summarizes the results of the field survey. Each reach sampled is described by number of sample points, land use, bank type, etc. According to the field survey data, the predominant land use is woodland with the predominant bank type soil being clay. The length of the streambank sampled ranged from a 50-foot minimum to a 950-foot maximum with the average bank height surveyed being 8 feet high. The estimated annual bank recession rate varies from 0.1 foot per year to 0.5 foot per year. Table 5 also presents the annual computed recession in cubic feet and tons.

Table 6 presents a summary of estimated annual sediment yield from streambank erosion on the Black River. Each reach is defined according to its annual calculated recession (tons/reach). The percentage sampled is derived from the total number of miles of reach surveyed divided by the total length of the reach. The streambank erosion rate was compiled by dividing the streambank sediment yield for each reach by the known reach mile. The percent of total streambank erosion occurring in each reach was calculated using the streambank sediment yield for each reach divided by the total sediment yield for the Black River. The streambank sediment yield for each reach was determined by dividing the recession per reach by the percentage of reach sampled. Table 6 shows that the reaches exhibiting the highest percent of total streambank erosion have the highest streambank erosion rate (Reach K, L, M). The total streambank sediment yield amounts to 14,400 tons.

Table 7 presents the estimated annual sediment yield from net streambank erosion. Each reach is defined according to its annual calculated recession (similar to Table 6). The annual calculated deposition is also defined for each reach. Net calculated streambank recession is the difference between the calculated recession and deposition for each reach.

The percentage sampled (similar to Table 6) is derived from the total number of miles of reach surveyed divided by the total length of the reach. The Net Streambank Erosion Rate is calculated by the Net Streambank Sediment Yield divided by the total length of the reach. The percent of total net streambank erosion is calculated by dividing the net streambank sediment yield for each reach by the total net streambank yield. The net streambank sediment yield is determined by dividing the net streambank recession of each reach by the percentage sampled (extrapolation factor).

Similar to Table 6, Table 7 also shows that Reach K, L, and M are the reaches which exhibit the highest percentage of total net streambank erosion. The total net streambank sediment yield amounts to 12,000 tons. This amount is

Table 5 - Typical Streambank Characteristics by Reach

Reach	Number of Sample Points	Land Use	Bank Type (Percent)	Length of Streambank Sampled (ft)		Bank Height Over Section Sampled			Estimated Annual Bank Recession Rate (ft/yr)		Annual Computed Recession (1)	
				Min.	Max.	Min.	Max.	Typical	Min.	Max.	cf.	Tons
C	5	Woodland	Sandy-clay	50	300	3.0	10.0	6.0	0.2	0.3	1,539	77
D	1	Woodland	Sandy-clay	100	100	3.0	3.0	3.0	0.2	0.2	60	3
E	15	Woodland	34-sand 66-clay	50	300	2.0	20.0	12.0	0.1	0.4	5,858	303
F	14	Woodland	40-sand 60-clay	100	600	5.0	15.0	12.0	0.1	0.5	10,000	520
G	47	Woodland	7-sand 93-clay	100	600	2.0	8.0	5.0	0.1	0.3	9,252	466
H	3	Woodland	clay	100	150	2.0	3.0	3.0	0.2	0.3	222	11
J	21	Woodland	clay	100	300	2.5	12.0	9.0	0.1	0.5	6,877	346
K	45	Woodland	37-sand 63-clay	100	950	2.0	15.0	10.0	0.2	0.5	52,060	2,699
L	49	Woodland	25-sand 75-clay	75	800	3.0	15.0	10.0	0.1	0.5	41,642	2,133
M	30	Woodland	15-sand 85-clay	100	400	3.0	12.0	10.0	0.1	0.5	16,653	845
N	5	Woodland	57-sand 43-clay	100	150	3.0	6.0	3.0	0.1	0.2	280	15

(1) Conversion Factors
Clay 20 cf = 1 ton   Silt 20 cf = 1 ton   Sand 18 cf = 1 ton

Table 6 - Estimated Annual Sediment Yield From Streambank Erosion, Black River

Reach (2)	Recession (tons/reach)	Percentage Sampled	Total Reach (miles)	Streambank Erosion Rate (tons/mile)	Percent of Total Streambank Erosion	Streambank (1) Sediment Yield (tons)
A	-	0	3.0	0	0	-
B	-	0	3.4	0	0	-
C	77	7.5	9.1	113	7.1	1,024
D	3	.5	4.1	149	4.3	612
E	303	22.3	10.4	131	9.4	1,360
F	520	31.3	9.7	171	11.5	1,659
G	466	85.0	15.7	35	3.8	548
H	11	28	6.8	59	2.8	398
I	-	0	5.5	149	5.7	821
J	344	41.7	11.4	72	5.7	825
K	2,700	98.9	14.6	187	19.0	2,730
L	2,133	92.1	6.6	351	16.1	2,316
M	846	43.7	6.0	322	13.4	1,935
N	15	8.4	14.4	12	1.2	175
Total	7,418	40.4	120.7	-	-	14,402 (10,700 CY)

(1) Total streambank yield per reach is determined by recession per reach divided by the percentage of reach sampled (extrapolation factor).
(2) See Figure 1 in Section A for location of reaches.

Table 7 - Estimated Annual Sediment Yield From Net Streambank Erosion, Black River

Reach (2)	Recession (tons/reach)	Deposition (tons/reach)	Net Streambank Recession (tons)	Percentage Sampled	Net Streambank Erosion Rate (tons/mile)	Percent of Total Net Streambank Erosion	Net Streambank Sediment Yield (1) (tons)
A	-	-	-	0	-	0	-
B	-	-	-	0	-	0	-
C	77	24	53	7.5	77	5.9	706
D	3	-	3	.5	146	5.1	600
E	303	40	263	22.3	113	9.9	1,179
F	520	114	406	31.3	134	10.9	1,297
G	466	40	426	85.0	32	4.2	501
H	11	-	11	2.8	58	3.3	393
I	-	-	-	0	149	6.9	821
J	344	121	223	41.7	47	4.5	535
K	2,700	381	2,319	98.9	161	19.6	2,345
L	2,133	314	1,819	92.1	299	16.5	1,975
M	846	204	642	43.7	245	12.3	1,469
N	15	5	10	8.4	8	.9	119
Total	7,418	1,243	6,175	40.4	-	-	11,940 (8,900 CY)

(1) Net streambank sediment yield per reach is determined by net streambank recession per reach divided by the percentage of reach sampled (extrapolation factor).

(2) See Figure 1 in Section A for location of reaches.

considered to be the amount of sediment delivered to Lorain Harbor. On this basis, it is estimated that streambank erosion accounts for about 8.8 percent of the average annual amount of dredging at Lorain Harbor (12,000 tons ÷ 136,000 tons X 100).

The results of Table 6 and Table 7 correspond to the results of the original Buffalo District Study compiled on Streambank Erosion for the Black River (Reference 11, Appendix A), namely that Reach K, L, and M are the reaches with the highest erosion.

Trash (dead trees, construction debris, etc.) is a contributing factor to the high rates of annual lateral recession at several locations. Trash buildup gouges the bank as it becomes lodged and deflects the stream flow either into the toe of the bank, causing undercutting, or into the river bed, causing scouring.

No correlation could be made between streambank erosion and soil type. The majority of the soils encountered were alluvium soils primarily composed of fine silts and clay having similar texture characteristics. As a result of the similar texture characteristics, no individual soil type appeared to be more susceptible to erosion than another.

As previously indicated, annual streambank erosion produces about 14,400 tons (9,500 CY) of sediment annually. A portion, 2,400 tons (1,500 CY) of this sediment, settles out before it reaches Lorain Harbor. This sediment either forms bedload bars, which usually contribute to the high rates of annual lateral recession, or is deposited on the inside of bends in the streams.

As previously discussed in Section B - "Problem Identification" of this Main Report, the Corps of Engineers annually dredges about 144,000 cubic yards (136,000 tons). This figure represents a 15-year average of sediment from the navigational channel and lakefront harbor at Lorain. By comparing the volume of sediment produced from annual net streambank erosion which reaches Lorain Harbor (12,000 tons) with the 136,000 tons of sediment dredged, it can be concluded that annual net streambank erosion accounts for only 8.8 percent of the sediment dredged and is insignificant. Therefore, other sources of sediment must be identified if an effective control program is to be implemented that would significantly reduce dredging at Lorain Harbor.

Meander Changes

As previously defined, meander changes are areas where the stream changes its course during a major runoff event. This course change is caused by erosion of the alluvium flood plain soils and typically occurs at large bends in the river (meander loops). When the river is confined to a narrow flood plain due to geologic features, meander changes do not occur.

In order to estimate the amount of bank displacement that occurred as a result of meander changes, previous river channel changes were identified and studied. The first step was to use aerial photos from the year 1938, 1951 and 1979 to depict the exact location of the river channel in those years. USGS topographic maps published in 1960 and 1963 with photo revision in the

1970's were used for cross reference. The results are presented in Plates 1-8 of Appendix A.

These plates were interpreted and major meander changes were identified at various river miles. Narratives describing the meander changes over a 41-year period can be found in paragraph A8 of Appendix A. The majority of meander changes occurred during 1938-1951, and the stream channel has been relatively unaltered in subsequent years.

The quantity of sediment which was displaced during meander changes was estimated. Table 8 presents the data used to estimate the quantity of sediment that would be displaced when meander changes occur. Also shown are the total bank material displaced and the average annual amount of material displaced.

Table 8 - Displacement of Bank Material on The Black River Over a 41-Year Period (1938-1979)

Meander Site	Average Bank Height (ft)	Length of New Channel (ft)	Width of New Channel (ft)	Total Bank Material Displaced (cy)	Yearly Bank Material Displacement (cy)
1	6	1,800	35	14,000	350
2	5	1,000	30	5,600	140
3	8	2,000	35	20,700	520
4	4	600	35	3,100	80
5	4	500	15	1,100	30
6	4	900	15	2,000	50
7	4	600	15	1,300	30
8	4	800	15	1,800	40
9	4	400	15	900	20
10	4	1,200	15	2,700	70
11	3	700	15	1,200	30
12	10	1,400	30	15,600	390
13	11	700	30	8,600	215
Total				78,600 cy	1,920 cy/yr 2,600 tons/yr

An estimated average annual quantity of 2,600 tons of sediment is displaced from meander changes. This volume is equivalent to the volume of sediment produced from approximately 3 months of annual net streambank erosion.

In summary, the total amount of sediment produced from both streambank erosion and meander changes amounts to approximately 14,600 tons (12,000 + 2,600) which represents only 11 percent of the average annual dredging quantity.

Annual Delivery to Lorain Harbor from Streambank Erosion and Meander Changes

Assuming that all the sediment from streambank erosion and meander changes is delivered to and deposited in Lorain Harbor, the total annual contribution from these sources would be about (12,000 from streambank erosion and 2,600 tons from meanders). This amounts to about 11 percent of the average annual maintenance dredging at Lorain Harbor. On this basis, it is concluded that bank and meander stabilization programs on the Black River and its branches would have very minimal effects on reducing annual maintenance dredging at Lorain Harbor.

Streambank Erosion Treatment Needs

The type of streambank erosion treatment needed along the banks of the Black River was identified by the field survey team. Selection of the streambank erosion treatment was determined by considering bank height, severity of erosion, cost maintenance and consideration for all environmental surroundings.

Table 9, Streambank Erosion Treatment Needs Assessment shows various streambank erosion treatment measures on the Black River and the quantity of such streambank erosion treatment needed for each particular reach (streambank erosion and bank displacement). Streambank erosion treatment measures were basically of five types, armoring, simple treatment, trash removal, management and deflection of deposition. In addition, combinations of erosion treatments (armoring/simple treatment), were cited on reaches of the Black River which required both treatments for effective streambank erosion control. A detailed description of these treatment methods is contained in paragraph A13 of Appendix A.

Table 9 lists the types of erosion treatment necessary for each reach with calculated percentages of amounts of streambank erosion control treatment needed for each reach. In addition, the various streambank erosion treatments were summarized and percentages of each particular erosion treatment were calculated. Armoring which represents 60.8 percent of streambank erosion treatment was the largest single erosion treatment on the Black River.

Table 10, Total Cost of Streambank Treatment on the Black River, presents data consisting of various combinations of streambank erosion treatment. Costs for Table 10 are based on similar projects from the Cuyahoga River, Ohio Restoration Study, updated to April 1982 price levels. Details of the streambank erosion treatment measures are presented in Appendix A. Table 10

Table 9 - Streambank and Treatment Needs Assessment, Black River

Reach	Armoring (1) (ft.)	Armoring/ Trash Removal(1) (ft.)	Simple Treatment (1) (ft.)	Armoring/ Simple Treatment (1) (ft.)	Trash Removal (1) (ft.)	Armoring/ Management (1) (ft.)	Armoring/ Deflection of Deposition (1) (ft.)	Deflection of Deposition (1) (ft.)	Management(1) (ft.)	Simple Treatment/Trash Removal (1) (ft.)	Management/ Simple Treatment (1) (ft.)	Total (1)	Percentage
A	-	-	-	-	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-	-	-	-	-
C	8,511	-	-	1,596	-	-	-	-	-	-	-	10,107	9.4
D	-	-	-	-	-	-	-	-	-	-	-	-	-
E	7,627	-	-	-	-	-	-	-	-	-	-	7,627	7.1
F	6,621	3,510	-	638	-	2,234	-	-	-	-	-	1,3003	12.0
G	9,004	794	412	141	1,824	-	-	-	794	471	-	13,440	12.5
H	3,584	-	5,376	-	-	-	-	-	-	-	-	8,960	8.3
I	-	-	-	-	-	-	-	-	-	-	-	-	-
J	7,931	480	-	900	-	-	-	-	-	-	-	9,311	8.6
K	9,960	4,070	101	834	506	-	-	-	-	-	-	15,471	14.3
L	4,722	4,147	1,943	2,280	304	-	-	1,086	-	163	271	14,916	13.8
M	4,760	4,108	458	1,693	-	-	1,167	-	-	-	-	12,186	11.3
N	2,962	-	-	-	-	-	-	-	-	-	-	2,962	2.7
Total	65,682	17,109	8,290	8,082	2,634	2,334	1,167	1,086	794	634	271	107,983	100.0
Percent	60.8	15.8	7.7	7.5	2.4	2.1	1.1	1.0	0.7	0.6	0.3	100.0	

(1) Extrapolated values.

shows the type of streambank erosion treatment measure required in linear feet. A total of 108,000 linear feet are necessary as erosion treatment measures. An average bank height of 8 feet was assumed in all calculations.

Table 10 - Total Cost of Streambank Treatment, Black River

Type of Treatment	Total Linear Feet Needed	Cost per Linear Foot (1)	Total Cost of Treatment
		$	$
Armoring	65,700	83.00	5,453,100
Armoring/	17,100	83.00	1,419,300
Trash Removal (2)		.50	8,600
Simple Treatment	8,300	2.00	16,600
Armoring/Simple	8,100	83.00	672,300
Treatment (2)		2.00	16,200
Trash Removal	2,600	.50	1,300
Armoring/	2,200	83.00	182,600
Management (1)		.10	200
Armoring/Deflection	1,200	83.00	99,600
of Deposition (2)	(4 jetties)		1,500
Deflection of Deposition	1,100	375/jetty	1,500
Deposition	(4 jetties)		
Management	800	.10	80
Simple Treatment/Trash	600	2.00	1,200
Removal (2)		.50	300
Management/Simple	300	.10	50
Treatment (2)		2.00	600
Total	108,000		7,875,000
			Say $8,000,000

(1) April 1982 price levels.
(2) Combinations of streambank treatment utilized data from Table A15. Where combinations of streambank treatment are found, the types of streambank treatment were used in conjunction with one another.

Deflection of deposition (jetties), however, were not based on the linear footage of streambank treatment needed. A price level was established per

foot of jetty construction. (Each jetty had a length of 15 feet.) Therefore, the cost of treatment was based on an established price for each jetty.

The total cost of streambank erosion treatment was calculated and amounts to approximately $8 million.

Table 11 presents a summary of benefits and costs for streambank erosion protection. The average annual charge is derived by taking the total cost of treatment ($8 million) and amortizing this amount over a 50-year project life at a 7-5/8 percent interest rate. Therefore, the average annual charge amounts to $626,000. The average annual benefits associated with mitigating streambank erosion and erosion due to meander changes is calculated by multiplying the net streambank erosion (8,900 cy) and erosion due to meander changes (1,920 cy) by the cost for dredging on the Black River ($3.42 per cubic yard - 1982 ICP unit price for dredging the Black River). The average annual benefits amount to approximately $37,000. Negative net benefits derived from controlling streambank erosion are $589,000 per year with the corresponding benefit-cost ratio of 0.06.

In conclusion, with significant negative net benefits and a benefit-cost ratio substantially below 1.0 (B/C = 0.06), it is considered that the implementation of the streambank treatment measures are not economically justified and should not be implemented.

Table 11 - Summary of Benefits and Costs for Streambank Erosion Protection

Average Annual Charge ($/Yr)	Average Annual Benefits ($/Yr)	Net Benefits ($/Yr)	Benefit-Cost Ratio
626,000	37,000	-589,000	0.06

UPLAND EROSION COMPONENT

General

The upland erosion component of this study is concerned with dislodgement and detachment of soil particles from the land surface and delivery of this sediment to a stream channel of the Black River. The analysis estimates sheet and rill erosion from agricultural and other nonurban land areas. These areas are generally referred to as diffuse sources of sediment.

Appendix B of this report contains a description of the Black River Watershed using a series of maps and tables portraying land slopes, soil properties, and land use. The details of the upland erosion calculations and delivery of sediment to the river system are then presented. Finally, possible erosion reductions are estimated and some Best Management Practices for agricultural land management are prescribed.

Methodology

The basic tool used in the upland erosion analysis is the Universal Soil Loss Equation (USLE). This is an empirical formula, developed by the Agricultural Research Service - U.S. Department of Agriculture, that calculates Potential Gross Erosion (PGE) based on six physical and land management parameters that influence the rate of erosion. Although there are numerous reservations regarding the use of this equation for large basin studies, the equation is recognized as the most reliable method for quantifying potential soil movement that is currently available. A detailed explanation on the use of this equation is in Appendix B.

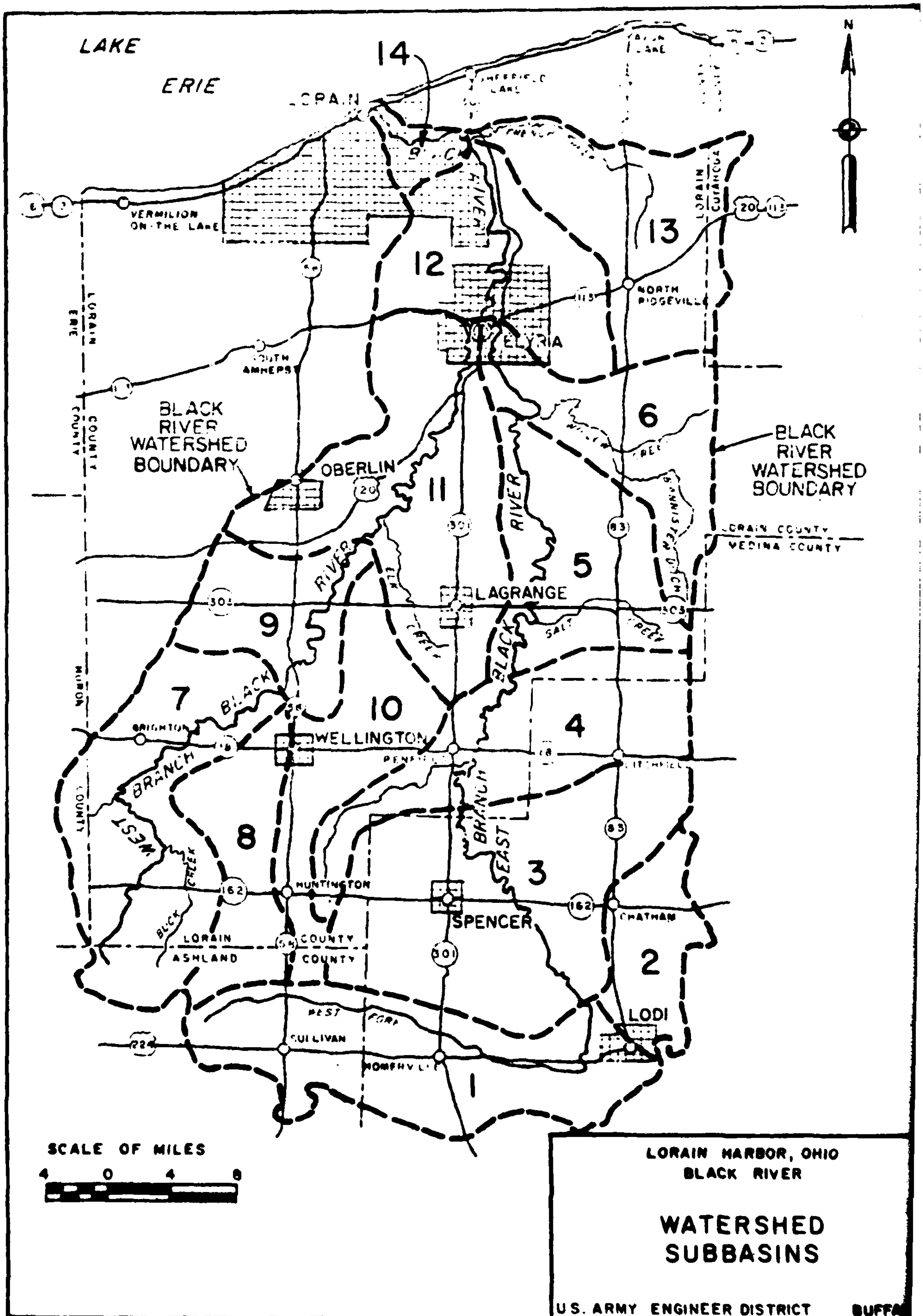
The USLE estimates the quantity of soil detached or dislodged from the land surface by raindrop action and the resultant runoff. It does not, however, measure or calculate the delivery of the eroded soil particle to a stream system. The calculation of the delivery ratio is discussed later in this section under the heading SEDIMENT EXPORT.

Existing Potential Gross Erosion

Potential Gross Erosion (PGE) was calculated for cropland areas and other agricultural and woodland areas by evaluating the USLE on a cellular basis (9 hectares in area) and summing to obtain the PGE at the subbasin level. The values of the potential gross erosion are presented by land use in Table 12 and by subbasin in Table 13. They are presented graphically on a "tons/acre" basis in Figure B8 of Appendix B.

For areas missing soil data, the assumption was made that land use distribution for missing data was the same as the land use distribution for which soils information was available. The average soil loss values in tons per acre per year for the particular land use with soils data was assigned to those assumed land uses with missing soil data.

As shown in Tables 12 and 13, approximately 835,000 tons of sediment is dislodged through sheet and rill erosion annually. Of this volume, 79.4 percent originates in cropland areas of the watershed, at a rate of 4.7 tons/acre/year. Land classified as vineyards, orchards, and woodland areas contribute relatively small amounts of erosion. Grassland and pastures produce a slightly greater amount of sediment, but much less than the cropland areas of the watershed. Urban soil losses are assumed to be negligible. Table 13 shows that subbasin number 7 exhibits the greatest amount of PGE (16.7 percent of the total PGE) at a rate of 5.4 tons/acre. Subbasin number 3 has the next highest PGE (14.2 percent of the total PGE), but at a lower rate (3.3 tons/acre). In general, the subbasins with the highest rates of erosion are located in the southern, steeper portion of the watershed.



LAKE
ERIE
14
LORAIN
VERMILION ON THE LAKE
12
13
NORTH RIDGEVILLE
ELYRIA
SOUTH AMHERST
BLACK RIVER WATERSHED BOUNDARY
OBERLIN
11
6
BLACK RIVER WATERSHED BOUNDARY
RIVER
RIVER
LORAIN COUNTY
MEDINA COUNTY
5
LAGRANGE
9
BLACK
SALT CREEK
7
BRIGHTON
BLACK
10
WELLINGTON
4
BRANCH
WEST
BUCK CREEK
8
BRANCH
EAST
HUNTINGTON
3
SPENCER
CHATHAM
LORAIN COUNTY
ASHLAND COUNTY
2
LODI
WEST FORK
SULLIVAN
1
SCALE OF MILES
4 0 4 8
LORAIN HARBOR, OHIO
BLACK RIVER
WATERSHED SUBBASINS
U.S. ARMY ENGINEER DISTRICT BUFFA

FIGURE

Table 12 - Existing Annual Potential Gross Erosion in the Black River Watershed by Land Use

Source	PGE (Tons)	PGE (Tons/Acre)	Percent of Total PGE for Basin
Cropland	662,921	4.7	79.4
Vineyards and Orchards	44	0.1	<0.1
Grassland and Pasture	64,655	1.5	7.7
Woodland	15,817	0.3	1.9
Estimate for Areas Miss-Soil Data	91,453	3.1	11.0
Total	834,890 say 835,000	2.7	100.0

Table 13 - Existing Annual Potential Gross Erosion in the Black River Watershed by Subbasin

Subbasin	PGE (Tons)	PGE (Tons/Acre)	Percent of Total PGE for Basin
1	80,730	3.2	9.7
2	38,370	3.2	4.6
3	118,760	3.3	14.2
4	66,200	2.6	7.9
5	59,610	2.5	7.1
6	27,500	1.4	3.3
7	139,350	5.4	16.7
8	96,550	5.9	11.6
9	45,080	2.8	5.4
10	69,180	3.7	8.3
11	61,830	1.8	7.4
12	13,200	0.8	1.6
13	18,380	0.7	2.2
14	150	0.1	<0.1
Total	834,890 say 835,000	2.7	100.0

Potential Reductions in Potential Gross Erosion

Scenarios were developed using the Universal Soil Loss Equation with the LRIS data base, to assess potential reduction of Potential Gross Erosion by application of cultural and land management practices to different cropland soil management groups. These groups, 10 in all, are characterized by the suitability of the land for the use of reduced tillage cropping management systems. Appendix B contains complete descriptions of these groups and a map showing their locations (Figure B7). The baseline against which the scenarios are compared is the estimated PGE for existing conditions. In the scenarios, tillage and cover conditions are evaluated for cropland only. Vineyards and orchards, grassland and pasture, and woodlands essentially remain the same in all scenarios.

The scenarios which were developed are as follows:

1. Existing Potential Gross Erosion.

2. Reduce Soil Loss to T - limits soil loss to the value which a soil in crop production can withstand over a long-term without reduction in crop yield. If existing PGE is less than T for a parcel of land the PGE is unchanged.

3. Spring Plowing Only.

4. Fall Plowing Only.

5. Planting of a Winter Cover Crop.

6. Maximum Reduction Tillage - a combination of no-tillage, reduced tillage, and present conditions, depending on Soil Management Group (these groups give a general indication of the suitability of land for the use of reduced tillage cropping management systems).

7. Reduced Tillage - a combination of reduced tillage and present conditions, depending on Soil Management Group (SMG).

The results are presented in Table 14. As shown, in order to reduce soil loss to "T or existing" a 46.1 percent reduction in PGE would be necessary. "Spring plowing" and "winter cover crops" result in minor reductions in PGE. "Fall plowing only" actually increases PGE since some cropland is presently under alternative management practices. Somewhat larger reductions are achievable through reduced tillage and maximum reduction tillage on suitable soils.

In order to determine preferred areas for any initial efforts of reduced tillage or no tillage implementation, the subbasins were ranked according to various "erosion reduction" criteria. These criteria included: (1) percent reduction in PGE, (2) total reduction in PGE in tons, (3) total reduction in PGE in tons per acre of cropland area, and (4) total reduction in PGE in tons per acre of cropland area actually under reduced tillage or no tillage. The highest ranking subbasins are located in the southern portion of the

watershed, as shown in Figure 4, where slopes are greater and soils are better drained. In other words, these are the areas where reduced tillage cropping management systems are most applicable and where the greatest erosion reductions can be realized. These subbasins also have high drainage densities (total length of streams per unit area), indicating a greater potential for export of eroded material. Therefore, erosion reductions would result in significant reductions in sediment delivery.

Table 14 - Potential Erosion Reductions

Scenario	Potential Gross Erosion (tons/yr)	Erosion Reduction (percent)
Present Condition	817,480	
Reduce Soil Loss to T and Existing	440,670	46.1
Spring Plow Only	788,320	3.6
Fall Plow	890,370	-8.9
Winter Cover Crop	802,900	1.8
Maximum Reduction Tillage	491,430	39.9
Reduced Tillage	617,110	24.5

The potential for reducing PGE in the Black River Watershed is limited by the large acreage of soils unsuitable for the erosion control practices of no till and reduced tillage farming (Soil Management Group 3 shown in Figure B7 of Appendix B).

An effort was made to map some Best Management Practices (BMP's) as a first cut step to start a design of a diffuse-source pollution control program (see Figure B11 of Appendix B). In the analysis, a variety of BMP's were specified over broad areas of land based on soil and topographic characteristics. These include the most suitable tillage system based on the characteristics of soils and erosion control practices which are based on the degree of slope of the land. The analysis resulted in the assignment of conventional tillage to 48.3 percent of the basin's area, reaffirming the fact that most of the agricultural soils are not suited to reduced tillage and no-tillage farming.

SEDIMENT EXPORT

General

The Universal Soil Loss Equation (USLE) is an effective tool in estimating the quantity of soil detached or dislodged from the land surface by raindrop action and the resultant runoff. It will predict the annual quantity of soil

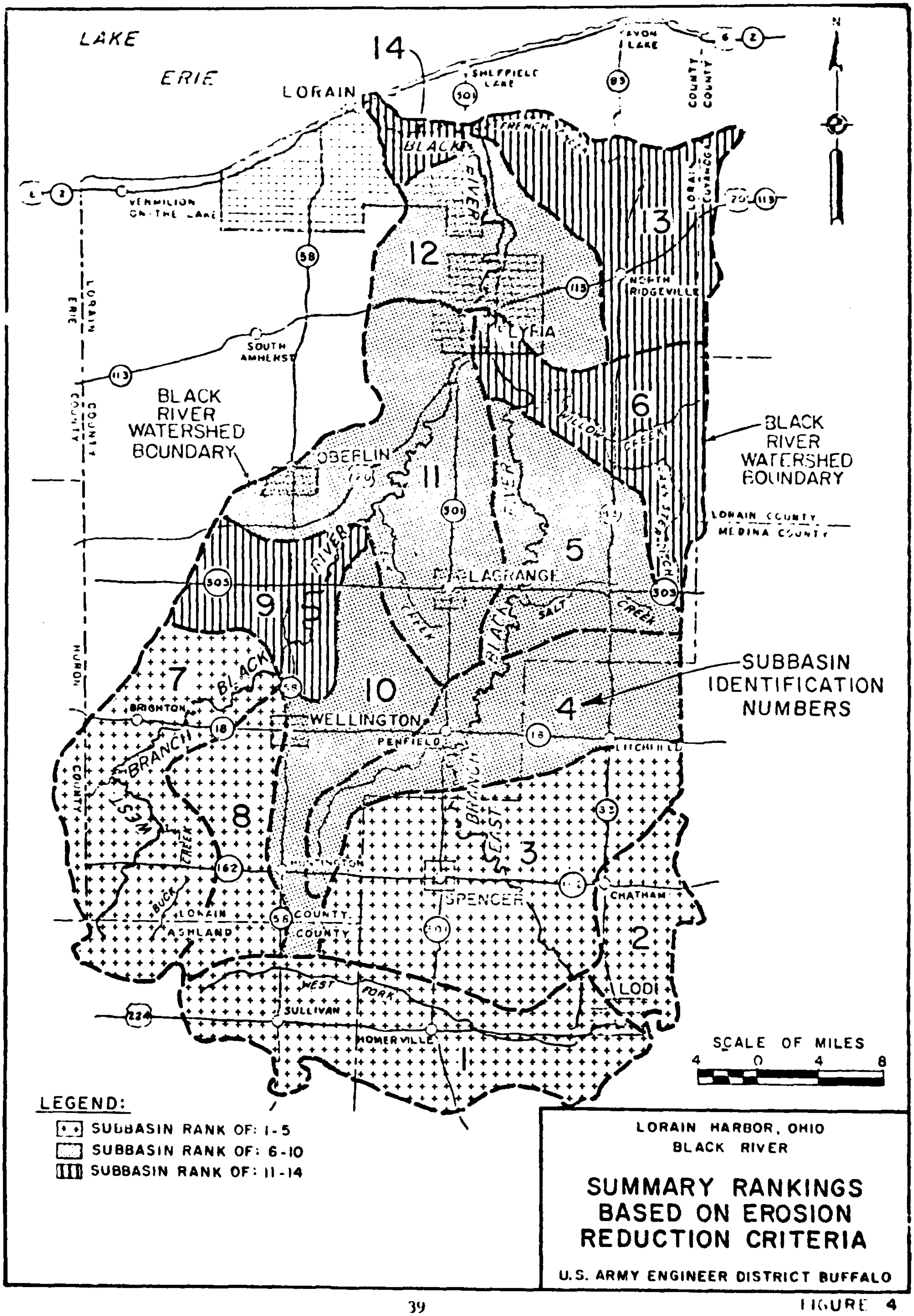

LAKE
ERIE
LORAIN
BLACK RIVER WATERSHED BOUNDARY
BLACK RIVER WATERSHED BOUNDARY
SUBBASIN IDENTIFICATION NUMBERS
OBERLIN
ELYRIA
NORTH RIDGEVILLE
SOUTH AMHERST
VERMILION ON-THE-LAKE
LAGRANGE
WELLINGTON
PENFIELD
LITCHFIELD
BRIGHTON
SPENCER
CHATHAM
LODI
SULLIVAN
HOMERVILLE
LORAIN COUNTY
MEDINA COUNTY
ASHLAND COUNTY
SCALE OF MILES
4 0 4 8
LEGEND:
SUBBASIN RANK OF: 1-5
SUBBASIN RANK OF: 6-10
SUBBASIN RANK OF: 11-14
LORAIN HARBOR, OHIO
BLACK RIVER
SUMMARY RANKINGS BASED ON EROSION REDUCTION CRITERIA
U.S. ARMY ENGINEER DISTRICT BUFFALO

FIGURE 4

movement from the area of dislodgement. The distance the soil particle travels and where it is next deposited is not measured in the USLE system. It does not measure or calculate the delivery of the eroded soil particle to a stream system. However, through sampling of suspended sediment and gaging of river discharge, the delivery of suspended sediment to the Black River can be estimated.

Sampling Programs

There are two sources of suspended sediment and river discharge data for the Black River Watershed. One source is a sampling program which was conducted as part of the Lake Erie Wastewater Management Study (LEWMS) in 1975 through 1977. A total of 101 samples were collected from the Black River at Elyria using an event sampling strategy. Load estimates were developed based on instantaneous flow-concentrations and daily flows over the period of record at the water level station. Through use of this data and the flow interval method, the mean annual suspended sediment discharge of the Black River at Elyria is estimated to be 89,300 tons.

The second source of data is a sampling program conducted by the USGS in 1980 and 1981 which included five locations in the Black River Watershed. Suspended sediment and discharge data was collected daily at two stations and periodically at the remaining three stations. The daily mean water discharge was used with a graph of concentration versus gage height to compute suspended sediment discharge in tons per day. These daily discharge values are then summed for the annual estimates. The results of this sampling program are presented in Table 15. The annual suspended sediment discharge at Elyria for the year 1 July 1980 to 30 June 1981 is estimated to be 91,600 tons, as compared to 89,300 tons by LEWMS procedures. Unit area loads for the Black River, the East and West Branch at Elyria and the West Branch near Oberlin are similar. The East Branch near Lagrange has a unit area load approximately one-half that of the other stations.

It was reported previously by Anttila and Tobin (1978) that most of the sediment transported by the Black River, as well as most Ohio streams, is in suspension. Mean annual bedload discharge, in percentage of mean annual suspended sediment discharge, is estimated to be less than 1 percent.

Table 15 - Results of USGS Sampling Program

Station Location	Annual SS Discharge (tons)	Mean Daily Discharge (cfs)	Flow-Weighted Mean Conc. (mg/l)	Unit Area Load (tons/acre/yr)
Black River at at Elyria	91,600	338	275	0.36
West Branch Black River at Elyria	44,000	145	309	0.40
East Branch Black River at Elyria (1)	47,600	193	250	0.34
West Branch Black River nr. Oberlin	18,300	69	269	0.35
East Branch Black River nr. Lagrange	15,700	100	159	0.18

(1) Estimates for East Branch Black River at Elyria were calculated by subtracting data for West Branch Black River at Elyria from data for Black River at Elyria.

Delivery of Eroded Material

The suspended sediment loadings calculated above originate from two sources:

(1) Sheet and rill erosion in the upland areas of the watershed, and

(2) Streambank erosion along the channel. As discussed previously, the streambank erosion portion of the suspended sediment load measured at Elyria is approximately 11,300 tons annually (assuming that 100 percent of the net eroded material is carried downstream through the gaging site). Therefore, the sediment produced in the upland areas of the watershed, delivered to the Black River, and carried downstream through the gaging site at Elyria is approximately 78,000 tons annually (according to LEWMS load estimates). This value is calculated by subtracting the sediment attributable to streambank erosion (11,300 tons) from the total estimated suspended sediment load (89,300 tons). Based on USGS loading estimates, the suspended sediment loading attributable to upland erosion is 80,000 tons annually (91,600 tons less 11,300 tons).

The ratio of erosion to suspended sediment discharge is termed the "delivery ratio." Essentially, it is the proportion of erosion that actually reaches the stream channel and is carried downstream. This ratio is assumed to be

1.0 for streambank erosion. For upland erosion the value can be calculated by dividing the potential gross erosion above the gaging site at Elyria (784,800 tons) into the suspended sediment discharge attributable to upland erosion (78,000 tons for LEWMS Loadings). This results in a delivery ratio of 0.098 (0.101 for USGS loading estimates). This indicates that approximately 10 percent of the annual potential gross erosion in the upland areas of the Black River Watershed is delivered to the stream system and transported downstream through Elyria to Lorain Harbor.

SECTION D - CONCLUSIONS

The purpose of this section is to briefly summarize the results of this investigation. This section presents information on the results of streambank erosion and the upland erosion control studies.

Summary Results of Streambank Erosion Control Studies

The purpose of the streambank erosion control studies conducted for this study was to identify and quantify sources of streambank erosion and to determine the feasibility of implementing streambank erosion control measures. The streambank component study area consisted of the main stem of the Black River, in addition to the East Branch, West Branch, and West Fork of the Black River.

Results of the studies conducted for this report indicated that of the 241 bank miles of streambank in the study area, only 11 percent were actively eroding. The studies also indicated that annual streambank erosion produces 10,700 cubic yards of sediment. Of this 10,700 cy of sediment, it is estimated that 8,900 cy is transported to Lorain Harbor (with an expected 100 percent delivery) and requires annual maintenance dredging. This volume of sediment represents 8.8 percent of the total volume of sediment annually dredged.

The study also concluded that past meander changes contributed 1,920 cubic yards of sediment each year. However, the majority of meander changes, and subsequently, the amount of bank displacement occurred between 1938 and 1951. Therefore, the bank displacement is not representative of the present condition.

The cost of the proposed streambank erosion treatment methods amounts to $8.0 million with negative net benefits of $589,000 and a benefit-cost ratio of 0.06. It has been determined that further study is not economically feasible and no overriding environmental or social benefits would be derived from implementation of these erosion treatments. Therefore, the conclusion of this report for streambank erosion control is that the no-action (do nothing) plan is the only course of action and no further investigation of streambank erosion is warranted.

Summary Results of Upland Erosion Control Studies

The purpose of this study of upland erosion in the Black River Watershed was to identify and estimate the amount of sediment produced from diffuse sources throughout the drainage basin and delivered to the Black River System. A series of management measures has been developed to control erosion in the upland area. Implementation of these programs must, however, be pursued by other (local) interests.

Results of the analysis indicate that there is considerable erosion occurring in the upland portions of the watershed. The Universal Soil Loss Equation analysis estimates the annual soil loss to be 835,000 tons. Approximately 80 percent of this erosion (663,000 tons) occurs on cropland areas of the

watershed at a rate of 4.7 tons/acre/year. Of this 835,000 tons of sediment produced it is estimated that 80,000 tons (USGS) is delivered to the Black River and requires annual dredging. This represents approximately 58.8 percent of the total amount of sediment dredged. Therefore, in order to significantly reduce dredging costs at Lorain Harbor, an effective erosion control program must be implemented in these eroding areas.

Implementation of maximum reduction tillage and reduced tillage techniques will reduce potential gross erosion by 39.9 percent and 24.5 percent, respectively. Greater reductions are not possible because nearly half of the cropland erosion occurs on soils which are somewhat poorly to very poorly drained and hydraulic conductivity is so slow that even tile does not provide adequate drainage. This indicates that implementation of alternative land management practices on these soils for erosion control purposes would not be feasible. Some erosion reductions would be realized by implementation of no-till and reduced tillage techniques in the southern, upland portions of the watershed where soils are most suitable. Analysis of Best Management Practices for agricultural land management indicates that costly and involved methods of erosion control, rather than a simple change in tillage technique, are necessary to significantly reduce erosion in the Black River Watershed.

Based on sampling program results, approximately 10 percent of the 835,000 tons of eroded material is delivered to the Black River system annually and subsequently transported to Lorain Harbor.

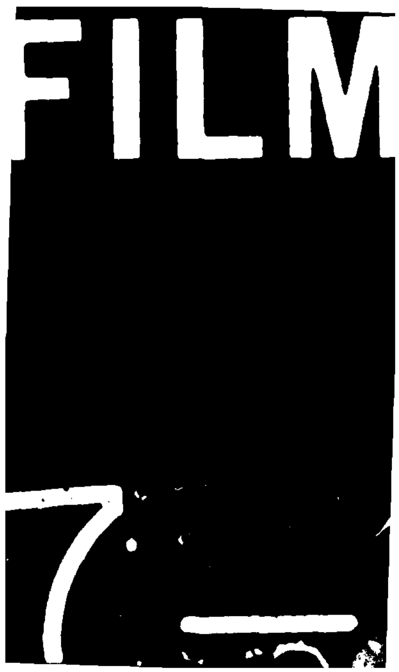
In conclusion, the streambank component and upland component account for 67.6 percent of the amount of sediment dredged from the navigational channel at Lorain Harbor. The remainder of the sediment (32.4 percent) can probably be attributed to the following factors. Only 84 percent of the entire Black River Watershed was accounted for in the Upland Component. The remaining 16 percent of the watershed is located downstream of the Elyria Gaging Station, which was not included as part of this study. Therefore, a possibility exists that a sizeable amount of sediment generated from French Creek Basin, located downstream of Elyria, was unaccounted for. Inaccuracies may have existed in the Universal Soil Loss Equation (USLE), conversion factors, dredging records, and field survey estimates. Also, the magnitude of sediment contribution from local sources, such as industry, runoff from streets, etc., have not been accounted for and could be significant.

SECTION E - RECOMMENDATIONS

Since streambank erosion control improvements cannot be economically justified, it is recommended that no further consideration be given to streambank erosion control improvements in the Black River Basin and that the sedimentation and erosion portion of the Lorain Harbor study be terminated.

In addition, it is recommended that local interests implement upland erosion measures (Best Management Practices) on eroding areas in the watershed. To assist in this effort it is also recommended that local interests seek professional advice from technical experts such as the United States Soil Conservation Service, the local Soil and Water Conservation Districts, and private consultants prior to implementing upland erosion control plans.

ROBERT R. HARDIMAN
Colonel, Corps of Engineers
District Engineer


FILM